A Guide to Aluminum Welding

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Equipment Selection, Material Prep, Welding Technique...
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Follow the rules of thumb offered here for selecting welding equipment, preparing base materials, applying proper technique, and visually inspecting weldments to ensure high-quality gas-metal-and gas tungsten-arc welds on aluminum alloys.

Even for those experienced in welding steels, welding aluminum alloys can present quite a challenge. Higher thermal conductivity and low melting point of aluminum alloys can easily lead to burnthrough unless welders follow prescribed procedures. Also, feeding aluminum welding wire during gas-metal-arc-welding (GMAW) presents a challenge because the wire is softer than steel, has a lower column strength, and tends to tangle at the drive roll.

To overcome these challenges, operators need to follow the rules of thumb and equipment-selection guidelines offered here...

Gas-metal-arc-welding:

Base-metal preparation: To weld aluminum, operators must take care to clean the base material and remove any aluminum oxide and hydrocarbon contamination from oils or cutting solvents. Aluminum oxide on the surface of the material melts at 3,700 F while the base-material aluminum underneath will melt at 1,200 F. Therefore, leaving any oxide on the surface of the base material will inhibit penetration of the filler metal into the workpiece.

To remove aluminum oxides, use a stainless-steel bristle wire brush or solvents and etching solutions. When using a stainless-steel brush, brush only in one direction. Take care to not brush too roughly: rough brushing can further imbed the oxides in the work piece. Also, use the brush only on aluminum work-don't clean aluminum with a brush that's been used on stainless or carbon steel. When using chemical etching solutions, make sure to remove them from the work before welding.

To minimize the risk of hydrocarbons from oils or cutting solvents entering the weld, remove them with a degreaser. Check that the degreaser does not contain any hydrocarbons.

Preheating: Preheating the aluminum workpiece can help avoid weld cracking. Preheating temperature should not exceed 230 F-use a temperature indicator to prevent overheating. In addition, placing tack welds at the beginning and end of the area to be welded will aid in the preheating effort. Welders should also preheat a thick piece of aluminum when welding it to a thin piece; if cold lapping occurs, try using run-on and run-off tabs.

The push technique: With aluminum, pushing the gun away from the weld puddle rather than pulling it will result in better cleaning action, reduced weld contamination, and improved shielding-gas coverage.

Travel speed: Aluminum welding needs to be performed "hot and fast." Unlike steel, the high thermal conductivity of aluminum dictates use of hotter amperage and voltage settings and higher weld-travel speeds. If travel speed is too slow, the welder risks excessive burnthrough, particularly on thin-gage aluminum sheet.

Shielding Gas: Argon, due to its god cleaning action and penetration profile, is the most common shielding gas used when welding aluminum. Welding 5XXX-series aluminum alloys, a shielding-gas mixture combining argon with helium - 75 percent helium maximum - will minimize the formation of magnesium oxide.

Welding wire: Select an aluminum filler wire that has a melting temperature similar to the base material. The more the operator can narrow-down the melting range of the metal, the easier it will be to weld the alloy. Obtain wire that is 3/64- or 1/16- inch diameter. The larger the wire diameter, the easier it feeds. To weld thin-gage material, an 0.035-inch diameter wire combined with a pulsed-welding procedure at a low wire-feed speed - 100 to 300 in./min - works well.

Convex-shaped welds: In aluminum welding, crater cracking causes most failures. Cracking results from the high rate of thermal expansion of aluminum and the considerable contractions that occur as welds cool. The risk of cracking is greatest with concave craters, since the surface of the crater contracts and tears as it cools. Therefore, welders should build-up craters to form a convex or mound shape. As the weld cools, the convex shape of the crater will compensate for contraction forces.

Power-source selection: When selecting a power source for GMAW of aluminum, first consider the method of transfer -spray-arc or pulse. Constant-current (cc) and constant-voltage (cv) machines can be used for spray-arc welding. Spray-arc takes a tiny stream of molten metal and sprays it across the arc from the electrode wire to the base material. For thick aluminum that requires welding current in excess of 350 A, cc produces optimum results. Pulse transfer is usually performed with an inverter power supply. Newer power supplies contain built-in pulsing procedures based on and filler-wire type and diameter. During pulsed GMAW, a droplet of filler metal transfers from the electrode to the workpiece during each pulse of current. This process produces positive droplet transfer and results in less spatter and faster follow speeds than does spray-transfer welding. Using the pulsed GMAW process on aluminum also better-controls heat input, easing out-of-position welding and allowing the operator to weld on thin-gage material at low wire-feed speeds and currents.

Wire feeder: The preferred method for feeding soft aluminum wire long distances is the push-pull method, which employs an enclosed wire-feed cabinet to protect the wire from the environment. A constant-torque variable-speed motor in the wire-feed cabinet helps push and guide the wire through the gun at a constant force and speed. A high-torque motor in the welding gun pulls the wire through and keeps wire-feed speed and arc length consistent.

In some shops, welders use the same wire feeders to deliver steel and aluminum wire. In this case, the use of plastic or Teflon liners will help ensure smooth, consistent aluminum-wire feeding. For guide tubes, use chisel-type outgoing and

plastic incoming tubes to support the wire as close to the drive rolls as possible to prevent the wire from tangling. When welding, keep the gun cable as straight as possible to minimize wire-feed resistance. Check for proper alignment between drive rolls and guide tubes to prevent aluminum shaving.
Use drive rolls designed for aluminum. Set drive-roll tension to deliver an even wire-feed rate. Excessive tension will deform the wire and cause rough and erratic feeding; too-little tension results in uneven feeding. Both conditions can lead to an unstable arc and weld porosity.

Welding guns: Use a separate gun liner for welding aluminum. To prevent wire chaffing, try to restrain both ends of the liner to eliminate gaps between the liner and the gas diffuser on the gun.

Change liners often to minimize the potential for the abrasive aluminum oxide to cause wire-feeding problems.

Use a contact tip approximately 0.015 inch larger than the diameter of the filler metal being used - as the tip heats, it will expand into an oval shape and possibly restrict wire feeding. Generally, when a welding current exceeds 200 A use a water-cooled gun to minimize heat buildup and reduce wire-feeding difficulties.